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BOOK REVIEW

English Translation of Bonghan Kim's Fifth Report: Bonghan Sanal—Cell Cycle of Blood Cells

1. On the translation

During 1962—1965, Dr. Bonghan Kim and his research team in North Korea published five reports on the Bonghan System, which was considered to be sensational because it was claimed to be the third vascular system in the body and, most importantly, the essence of the acupuncture meridian. Recently, English versions of the first four reports were located in various parts of the world but the English version of the fifth report had still not been found. This article is the English translation of Kim's Fifth Report, which deals with the blood cell regeneration in the Bonghan System. Kim's study results were far ahead of his time and even now. Selected parts of Kim's results in the first four reports were studied and examined by other scientists and they were proven to be valid, although the many of the remaining parts are still to be studied. The contents of the fifth report appear unusual and almost unbelievable, particularly for the scientists who are not familiar with the Bonghan System (or primo vascular system; PVS). The intent of translating this report does not necessarily imply that this author takes Kim's results as absolute scientific facts. The author, however, strongly believes that this report content is worthy of further investigation because the data presented in the report have details that appear difficult to fabricate. If Kim's findings in the report are valid as other findings in his previous reports, the findings may be scientifically significant because they contain completely new aspects on blood cell regeneration, that is, regeneration via the Bonghan sanal—cell cycle, and, therefore, could be beneficial for future healthcare management.

The copy of Kim's Fifth Report was provided to this author as a photocopy in black and white; perhaps a re-copied version after several copies, and the original of this copy has never been found. Thus, most figures of experimental results are of low resolution/quality, which is different from those in the English versions of his first four reports. The figures are however included in this translation because the report content was thought to be better understood with them. The author hopes that the original English version of the report will be located soon so that we can study the high-quality color images that Dr. Kim produced > 50 years ago. The copy did not have its cover pages and starts from a part of the table of contents in Russian and Chinese.

The English translation of Dr. Kim's Korean report was not easy because some of the Korean words in it are slightly different from current Korean words. In addition, many non-Korean, biological or medical terms were written phonetically in the Korean alphabet, which made it difficult to identify the original words. To honor Dr. Kim's efforts, significant effort was made to describe the report content accurately, while retaining the original expressions and format as much as possible.

Readers who are not familiar with the Bonghan System are suggested to review English versions of Kim's first four reports, listed here, which are available via www.ispvs.org: (1) Kim BH (1962) Great Discovery in Biology and Medicine — Substance of Kyungrak — Foreign Language Publishing House, Pyongyang, Democratic People's Republic of Korea; (2) Kim BH (1964) On the Kyungrak System The Kyungrak Institute, Pyongyang, Democratic People's Republic of Korea; (3) Kim BH (1965) Kyungrak System, Proceedings of the Academy of the Kyungrak of the Democratic People's Republic of Korea, Pyongyang, 1965(2):9—67 Medical Science Press, Pyongyang, Democratic People's Republic of Korea; and (4) Kim BH (1965) Sanal Theory, Proceedings of the Academy of the Kyungrak of the Democratic People's Republic of Korea, Pyungyang, 1965(2):69—104 Medical Science Press, Pyongyang, Democratic People's Republic of Korea

Since 2010, the Bonghan System has also been known as the PVS. Therefore, readers who would like to review the recent publications on the same system should search scientific information under the key words of "Primo Vascular System" or "PVS".

The author thanks Professor Kwang-Sup Soh for his comments on and help with the translation.

It should be noted that the *italicized* texts in the article are the author's (not Kim's) comments.

Bonghan Sanal—Cell Cycle of Blood Cells. Kyungrak Research Institute of People's Democratic Republic of Korea

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2. Preface

Although it has been known for a long time that blood cells are continuously renewed, the origin of blood cells and their differentiation processes have been described by various hypotheses; mainly based on the traditional cell theory. If the cells were produced only by cell division, then this theory fails to demonstrate the existence of the large number of participating blood-cell origins and actual experimental validation of them. Therefore, there have been many debates on the theory of the origin and differentiation of blood cells.

The Kyungrak System and Sanal Theory, which have already been reported, raise the possibility of explaining the issues above (*Sanal is a Korean word for 'live egg,' defined by Kim*). My analyses here are based on the principle of the Sanal Theory, that is, all tissues are self-reproduced by the way of the Bonghan Sanal—Cell Cycle via the meridian system, and I then analyzed the origin and differentiation processes of blood cells, accordingly.

3. Red blood cells

In our studies, we have used domestic rabbits as the main experimental animal. The nucleus-less (NL) red blood cells (RBCs) in the peripheral blood can be sanalized (i.e., *cells becoming sanals; defined by Kim*) by several experimental methods, and all sanals produced by these methods have the same characteristics. A single nucleus-less red blood cell (NLRBC) produces 10—20 NLRBC sanals. The size of usual NLRBC-sanals is 1.2—1.5 μm, and they can be as small as 0.8 μm and as large as 2.5 μm. Sanals are round or oval. The NLRBC sanal does not have the sanalosome (*the content with large amount of nucleic acid inside the sanal; according to the Bonghan Kim's Fourth Report*).

3.1. Electron-microscopic observation of NLRBC sanals

NLRBC sanals are round or oval and are homogeneously and densely packed with fine, net-like or particle-like materials of high electron density. Inside the sanal, particles with high electron density are scattered. The sanal boundary is well defined and covered with thin and delicate membranes, and the membranes sometimes exhibit a high electron density (Figure 1).

The NLRBC sanals in the internal Bonghan duct are structurally the same as those in the internal Bonghan corpuscle. NLRBC sanals are easily destroyed under various conditions, as are NLRBCs. NLRBC sanals disintegrate at high or low temperature, and sensitively respond to the change in osmotic pressure. NLRBC sanals are shown in brass or red color by hematoxylin and eosin stain. NLRBC sanals respond negatively to the Feulgen reaction and positively to the Brasche reaction. The NLRBCs going through sanalization process are stained pink by May—Giemsa staining, and their inside reveals the sanal constituents, strongly stained by eosin.

Cultured NLRBC sanals mature to become NLRBCs. During NLRBC sanal culture, the sanals increase their diameters: at Time 0, 1.5 μm (Figure 2A); at 12 hours, 3—4 μm

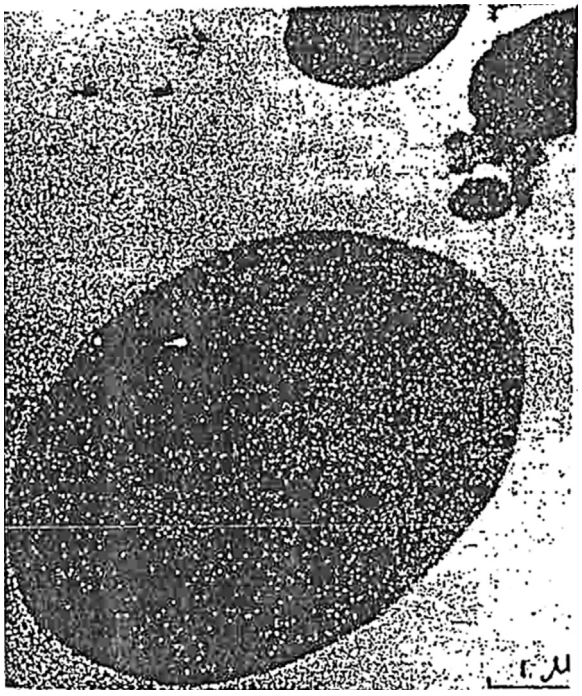


Figure 1

(Figure 2B); at 48 hours, 5—6 μm (Figure 2C); and at 96 hours, 6—7 μm (Figure 2D), that is, they become NLRBCs. The maturation process inside the sanals, however, may not be observed due to the high concentration of the blood chromophore (i.e., *hemoglobin*) inside, and when these sanals are manually squeezed, one can observe multiple sanals merging together. NLRBC sanals become NLRBCs without going through any stage with nuclei. When the biomolecules of the NLRBC Bonghan Sanal—Cell Cycle are

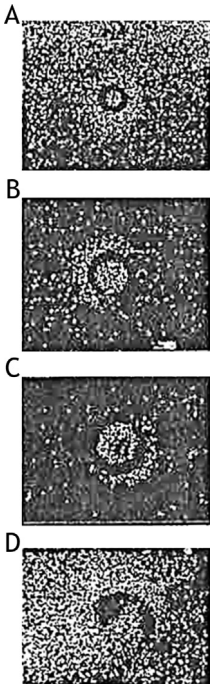


Figure 2

analyzed, unlike Bonghan sanals of other tissue cells, there is no DNA in the sanals, but there are RNAs and the blood chromophore. As the sanals mature, the amount of RNA decreases, the blood chromophore and protein increase, and the oxidase activity decreases.

3.2. Major biomolecular composition of NLRBC sanals

3.2.1. Nucleic acids, nitrogen, hemoglobin, sugar, and fat of NLRBC sanals

Separation of nucleic acids in the RBC sanals was done by a method based on the Schmidt—Tannhauser method, and their quantification was performed by the orcinol colorimetric assay and direct UV absorption method.

Nitrogen was quantified by the micro-Kieldahl method; hemoglobin, the cyan-methemoglobin method and hydrochloric hematin method; reduced sugar, the Hagedorn—Jensen method; and fat, the Bang method. The analysis results are shown in Table 1. As can be seen in Table 1, NLRBC sanals do not contain DNA and they have large amounts of RNAs and proteins, instead. In addition, the amount of reduced sugar and fat in the NLRBC sanals is not insignificant.

3.2.2. Characterization of RNA in NLRBC sanals

RNA extraction from NLRBC sanals was done by a method based on the phenol method suggested by Kirby and Georgiev, and the quantification was done by UV spectrometry. According to the analysis of the RNA in the RBC sanals, 60% was in a highly polymerized form and the remaining 40% in a form of low polymerization. As stated above, the RBC sanal is unique in the sense that it possesses a greater amount of low-polymerization RNAs, compared to those of other sanals.

3.3. Biomolecular activities of RBC sanals during RBC formation

In order to investigate the biomolecular activities during RBC formation from the RBC sanal, the RNA, hemoglobin, and activities of cytochrome oxidases and catalases were quantified at various stages. RBC sanals were cultured for 48 hours and 72 hours, and they were analyzed by phase contrast microscopy.

3.3.1. Amount of nucleic acid and hemoglobin with changes in culture time

Table 2 shows the changes in the amount of nucleic acid and hemoglobin with respect to the culture time.

Table 1

Content	Amount (%)
Water	65.0—75.0
Dry matter	25.0—35.5
Protein	19.69—23.71
Hemoglobin	2.50—3.50
Total fat	0.32—0.45
Reduced sugar	0.15—0.24
DNA	—
RNA	0.12—0.16

Table 2

Culture time (h)	Composition		
	DNA	RNA	Hemoglobin
0	0	57.5	0.15
48	0	12.2	0.80
72	0	0.9	1.50

Results shown per ml culture medium

Table 3

Culture time (h)	Oxygen uptake rate (μL)
0	19.77
48	11.69
72	2.59

Compared to Time 0, the amount of RNA decreased significantly and hemoglobin increased at 72 hours.

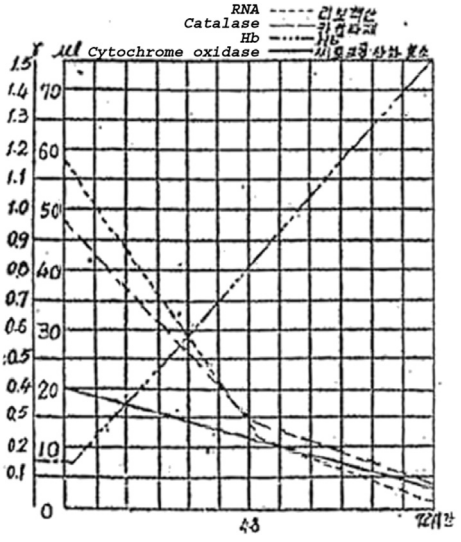
3.3.2. Cytochrome oxidase activity

The activity of cytochrome oxidase was quantified by the Warburg method at various culture times. The oxygen uptake is shown in the Table 3. According to the analysis, the oxygen uptake rate by the RBC sanals was the highest at Time 0, and decreased with time.

3.3.3. Quantification of catalase activity

The change in catalase activity with culture time was quantified in terms of the amount of oxygen produced per unit time (Table 4). The table shows that catalase activity is high at the beginning of the culture and decreases as the RBCs mature.

The figure below shows the combined changes in the amount of major biomolecules in the RBC sanals, with respect to culture time.



The amount of RNA decreases and hemoglobin increases with time. During this time period, the activities of cytochrome oxidase and catalase rapidly decrease. This implies that the metabolism of RBC sanals during the stage of RBC

Table 4

Culture time (h)	Amount of oxygen production (μL)
0	46.71
48	14.80
72	3.64

formation is active, and decreases as they mature to become RBCs. These findings suggest that the genetic characteristics during RBC formation are determined by the sanals that are mainly composed of RNAs and proteins. The process of RBC formation from RBC sanals and RBC sanalization from RBCs can also be seen in *in vitro* culture as well as *in vivo*.

RBC sanalization can be seen in the sinusoids inside the inner structure of the superficial Bonghan corpuscles (Figure 3), and the formed sanals are transported to the Bonghan duct sinusoid of the inner structure, and then flow through the internal Bonghan ducts.

Similar phenomena can be seen in the external Bonghan corpuscles. The RBC sanals flowing via the internal Bonghan ducts enter the internal Bonghan corpuscles and become mature there. Inside the internal Bonghan corpuscle, one can see the individual stages of the sanal maturation. The mature RBCs are then transported into the bloodstream.

In any case, an interesting phenomenon to see is, along with the NLRBC sanals, the RBC sanals with nuclei (NRBC sanals) maturing to become RBCs with nuclei (NRBCs). The process of nucleus removal from the NRBCs has not been observed. In the internal Bonghan corpuscles, NRBCs are formed less than NLRBCs.

The formation of RBCs in the internal Bonghan corpuscles occurs mainly in the Bonghan corpuscles inside blood vessels and also occasionally in the corpuscles inside lymphatic vessels.

Inside the bone marrow, as in the internal Bonghan corpuscle, one can observe the stages of NLRBC maturation from the NLRBC sanals and that of NRBCs from NRBC sanals.

When the external layer of the marrow under culture is studied by phase contrast microscopy, individual stages of the NRBC sanals becoming NRBCs can be observed. The processes can also be observed in the Bonghan ducts inside the external and intra-external Bonghan corpuscles.

4. Granulocytes

The Bonghan Sanal—Cell Cycle of the granulocytes, under culture conditions, is not different from that of other cells.

In vivo, sanalization of granulocytes occurs inside the sinusoid of the Bonghan corpuscle. The sanalization of the granulocytes can be seen inside the sinusoid in the superficial Bonghan corpuscle. The size of the granulocyte sanal is 0.9—1.0 μm. The granulocyte sanals formed by this way flow into the Bonghan duct sinusoid, via the internal Bonghan duct, and then to the internal Bonghan corpuscle. The sanalization of the granulocytes also occurs in the bone marrow (Figure 4).

The cellation (*phenomenon of sanals becoming cells*) process of the granulocytes occurs in the Bonghan corpuscle, particularly inside the Bonghan duct sinusoid of the internal Bonghan corpuscle, and also inside the Bonghan ducts in the bone marrow.

Granulocyte sanals mature as they go through a phase of basophilic substances and then form round-shaped, nucleus-like matters. These round-shaped, nucleus-like substances develop to become various types of cells.

The process of neutrophilic granulocyte sanals becoming neutrophilic granulocytes is as follows. As the round, nucleus-like substance matures, the cytoplasm is formed. In the cytoplasm, there are no granules yet, and the

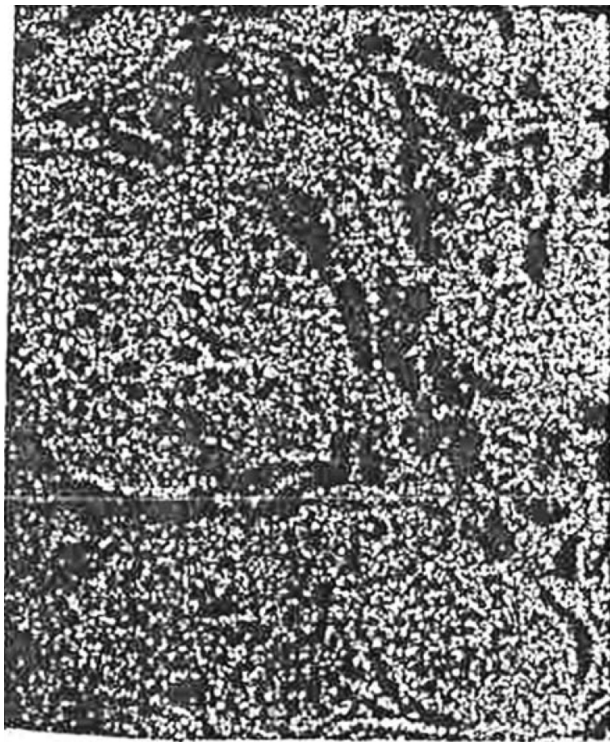


Figure 3

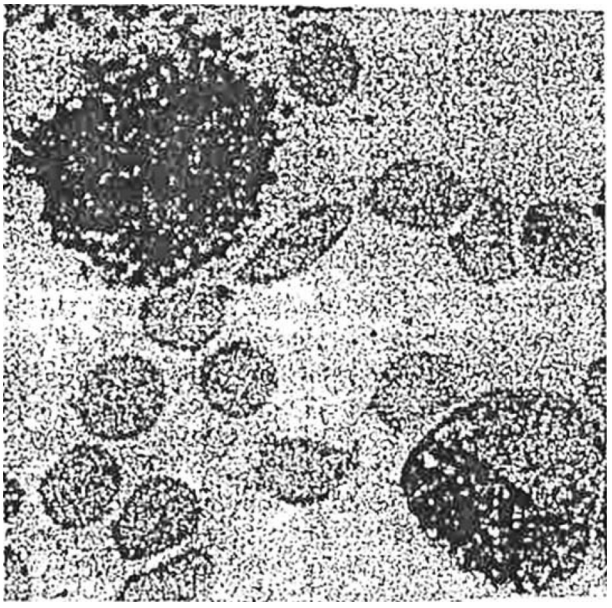


Figure 4

nucleus is positioned at the cell center in a hazy, circular form. The nucleus is stained dark by basic dyes, thus, its inner structure may not be recognized. As the cytoplasm matures, a small number of unclear, neutrophilic granules appear. The nucleus configuration is either not well defined or kidney shaped, and chromatin appears hazy and dispersed. The cytoplasm and nucleus gradually form typical, neutrophilic granulocytes. Eosinophil granulocytes also undergo a similar maturation process.

5. Lymphocytes

Under *in vitro* culture conditions, the Bonghan Sanal—Cell Cycle for lymphocytes is the same as that for regular cells.

In vivo, sanalization of lymphocytes occurs in the lymphatic system and Bonghan corpuscles. The cellation of the lymphocyte sanals occurs in the Bonghan corpuscles; particularly inside the internal Bonghan corpuscles in lymphatic vessels and in the lymph nodes. The cellation of lymphocyte sanals takes place in the external and intra-external Bonghan corpuscles.

6. Organs producing blood cells

If blood-cell producing organs, for example, bone marrow, lymph nodes, and spleen, are carefully examined, well-developed Bonghan duct sinusoids in a net-like structure, together with the blood vessel network, can be observed, as in the Bonghan corpuscles; and inside them, the cellation process of blood cell sanals can be seen; and inside their blood and lymphatic vessels, the sanalization process of blood cells is seen.

6.1. Meridian organization in the bone marrow

With regards to the anatomical characteristics of the bone, the meridian system distribution in the bone marrow is unique in several aspects, compared to that in other organs.

The internal Bonghan ducts are distributed in the bone marrow via the blood vessels in the marrow, but they protrude into the wall of small blood vessels and gain access to the bone marrow structures, forming a beehive-like, primary network. Some branches come out of the marrow surface to form the secondary network in the inner-layer surface of the bone (Figure 5).

The Bonghan ducts, after coming out of the blood vessels, show structural characteristics of the intra-external Bonghan ducts. These intra-external Bonghan ducts form dense networks and are connected to the cell nuclei.

Inside the Bonghan ductules, Bonghan sanals in various maturation stages are seen. When these Bonghan sanals mature to form a round nucleus configuration, the nuclei are connected to Bonghan ductule branches, and line up around the Bonghan ducts. Then, these round nuclear structures gradually mature.

6.2. Meridian organization in lymph nodes

The meridian distribution inside lymph nodes is similar to that in the bone marrow. The internal Bonghan ducts

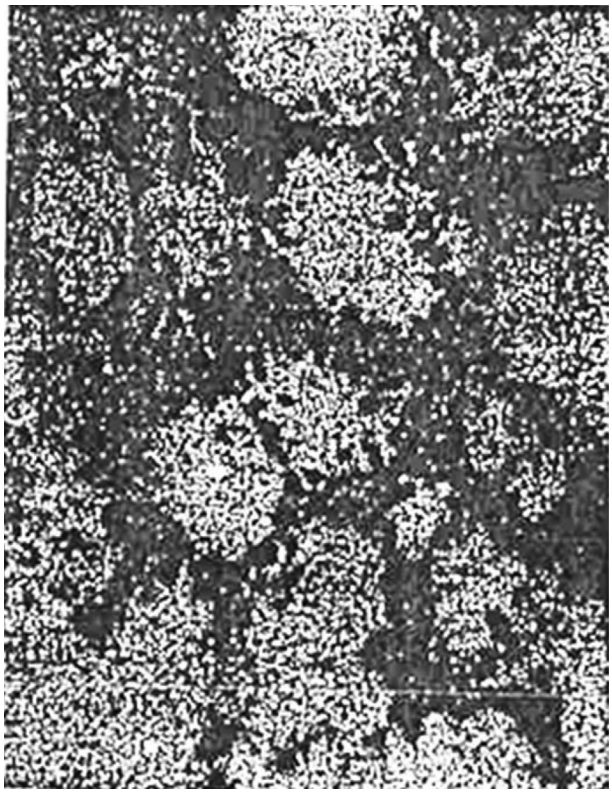


Figure 5

arriving at the lymph nodes via blood vessels come out of small (~20 μm) blood vessels and become intra-external Bonghan ducts. They form beehive-like networks in the capsules, trabecula, lymphoid nodules, and medulla, which are independent of blood vessels or nerves. They also form complex networks inside the lymph sinus, and are connect to the cell nuclei and immature nuclear-like material.

The intralymphatic, internal Bonghan ducts, entering the lymph nodes via lymphatic vessels, form lymphatic intra-external Bonghan ducts in the lymph sinuses, form net-like structures, and are distributed in small lymphoid nodules and medulla. The intra-external Bonghan duct networks, which are transformed from the internal Bonghan ducts in the blood and/or lymphatic vessels, merge to form extensive web-like networks; are distributed in the capsules, trabecula, lymphoid nodules, medulla, and lymph sinuses; and become connected to the cell nuclei and nucleus-like material (Figure 6). At the proliferative center of lymphatic nodules, their distribution is minimal.

7. Studies on Bonghan Sanal—Cell Cycle of blood cells by autoradiography micro-imaging

To understand the *in vivo* behavior of blood cell Bonghan sanals, radioactive tracers have been used experimentally. RBCs were labeled with C^{14}-adenine, and granulocytes and lymphocytes were labeled with $Na_2HP^{22}O_4$. Unreacted free tracers were completely removed from the labeled cell suspension. The cells were injected into the ear vein of the animal models and the animals were studied for 20 days.

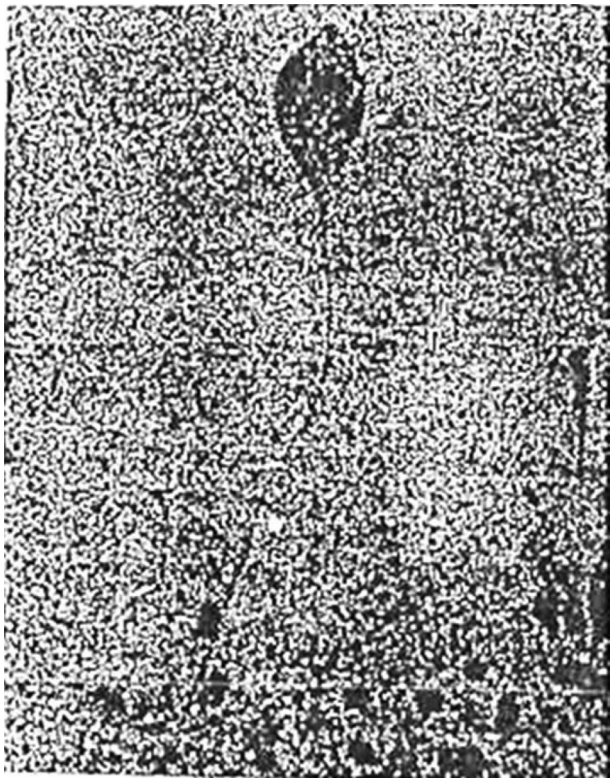


Figure 6

The organs examined were the bone marrow, liver, spleen, lymph nodes, superficial Bonghan corpuscles, and internal Bonghan corpuscles in the blood and lymph vessels. The autoradioactivity was imaged by the liquid—emulsion smearing method and, for the emulsion, NUC-715 was used.

7.1. Bonghan Sanal—Cell Cycle of labeled RBCs

From 2 days to 8 days after the labeled RBCs are injected into the ear veins of the animals, the sanalization process of the labeled RBCs can be observed in the sinusoids of the superficial Bonghan corpuscles. RBCs before sanalization and RBC sanals after sanalization can be seen inside the sinusoids. Also, inside the bone marrow, labeled RBC sanals of 0.5—1.0 μm are seen. In the same sections containing these labeled sanals, RBC sanals ranging 3—6 μm are also present. The configuration of the 6-μm cells is not much different from the RBCs. Also, inside the internal Bonghan corpuscles, RBCs maturing from the labeled RBC sanals can be observed.

7.2. Bonghan Sanal—Cell Cycle of labeled granulocytes

To study the behavior of labeled granulocytes *in vivo*, a section of bone marrow was cultured *in vitro* and examined. In the bone marrow, individual stages of the sanalization of the labeled granulocytes could be observed. From a single granulocyte, 10—12 labeled sanals are produced. In the bone marrow, one can also see the individual stages of labeled sanals, which are generated from the labeled granulocytes, maturing to become white blood cells. Also inside the internal Bonghan corpuscle, one can observe the maturation process of labeled granulocyte sanals (Figure 7).

7.3. Bonghan Sanal—Cell Cycle of labeled lymphocytes

The sanalization process of labeled lymphocytes can be observed in the white pulp of the spleen and also in some part of the red pulp. The formed, labeled sanals mature in the lymph nodes. These labeled sanals mature to become lymphocytes with dense, basophilic nuclei of 5—6 μm and with little cytoplasm. In the Bonghan ductules inside the internal Bonghan corpuscles, labeled lymphocyte sanals are seen, and inside the net-like structure, fully matured lymphocytes are observed (Figure 8). Mature, labeled blood cell sanals go through the same cycle as the regular sanals. The labeled blood cell sanals can be seen also in the Bonghan corpuscles and ducts.

8. Blood cell production in the internal Bonghan system during induced anemia

Domestic rabbits were intramuscularly injected in their buttocks with 4% basic phenylhydrazine in physiological saline, at 0.5 ml/kg body weight, 3—4 times a day. The hematocrit and hemoglobin level in the blood decreased to 245 and 11% of their normal levels, respectively.

The RBCs showed structural changes caused by serious hemolysis. Samples of thin bone marrow sections showed a

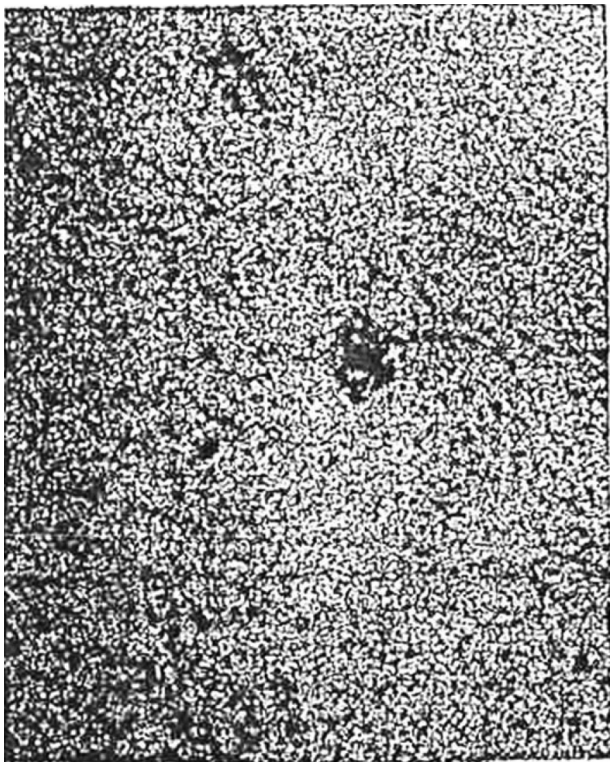


Figure 7

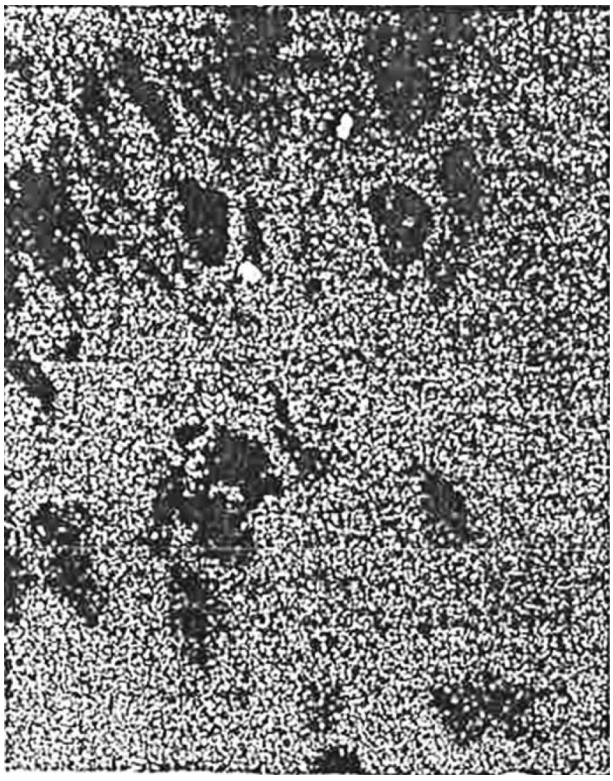


Figure 8

significant increase in reticular tissue cells. Their cytoplasm possessed a large amount of yellow granules, significantly enlarged, and their nuclei were off-center.

The overall appearance of the bone marrow looked damaged. During this stage, the size of the internal Bonghan corpuscles inside the blood vessels increased to 1.5—2 times their normal size and their number also increased. The corpuscles became solid and dense, and the Bonghan ducts connected to them were also expanded.

For the internal Bonghan corpuscles in the blood vessels, the RBCs inside the corpuscles showed little change and their number was high. The internal Bonghan corpuscles maintained their functions, became enlarged, and their number increased, and their Bonghan ducts were expanded. Also, when the bone marrow function for producing RBCs was limited by applying 1% lead acetate solution, to induce artificial anemia, the size of the internal Bonghan corpuscle expanded to 2—3 times of the normal size. The internal Bonghan corpuscles and ducts were enlarged. RBC production in the enlarged internal Bonghan corpuscle increased significantly; the number of the NLRBC sanals increased; and the number of formed, immature RBCs increased. However, the NRBC system did not change significantly. The internal Bonghan ducts also became larger and their ductule walls became thicker. The Bonghan corpuscles were filled with many RBC sanals; the sanal size was 0.8—1.5 μm; and there were also small RBCs. Similar phenomena could be observed in the internal Bonghan duct system, when some pathogenic microorganisms were injected into the blood vessels. The internal Bonghan corpuscles also became larger and their number increased.

Inside the expanded internal Bonghan corpuscles, a large amount of nucleus-like substances and basophilic granules appeared, along with a significant amount of immature eosinophilic and neutrophilic granulocytes, and mature granulocytes. Initially, only nucleus-like material increased, followed by eosinophilic granulocytes, and then neutrophilic granulocytes.

When white blood cells in the peripheral blood decreased, Bonghan corpuscles became active and cellular material decreased. Inside the internal Bonghan ducts, the basophilic cellular substances and basophilic granules significantly increased. However, RBC formation was limited or, in extreme cases, ceased.

The blood cell formation in the internal Bonghan system during the pathophysiological conditions described above more clearly revealed the Bonghan Sanal—Cell Cycle process of blood cells.

9. Conclusion

9.1. Self-regeneration process of blood cells follows Bonghan Sanal—Cell Cycle

Sanalization of RBCs, granulocytes, and lymphocytes may be done *in vitro* and the resulting sanals may be cultured to develop the respective blood cells. The sanalization and cellation processes of granulocytes and lymphocytes are the same as those of other cells. The cellation process of granulocyte sanals is by the following route: Sanals → Basophilic, structural substance formation → round, nucleic substance formation → granulocyte. Between the stages of the round, nuclear substance formation and the granulocyte, the early granulocyte maturation process, which was hypothesized in the traditional theory, is rarely observed.

The sanalization and cellation processes of NLRBC are unique. NLRBC sanals do not have sanalosomes and, in the process of cellation, RBC sanals appear to expand concentrically. However, if the maturing RBC sanals are squeezed, one can observe multiple sanals merging together. NLRBC sanals do not possess DNA, and RNA is relatively abundant compared to the NLRBCs. As the sanals mature, the amount of RNA is reduced and the RBC chromophore increases, and the oxidase activity decreases.

RBCs, granulocytes, and lymphocytes are also self-regenerated *in vivo* via the Bonghan Sanal—Cell Cycle. The blood cell sanalization and cellation processes can be observed *in vivo*, as seen in *in vitro* culture. Regeneration of blood cells is performed in two different ways: cell division via the intracellular Bonghan Sanal—Cell Cycle and the extracellular Bonghan Sanal—Cell Cycle, independently. However, the latter is prevalent, while the former is rare. By taking the latter route, a large amount of blood cell regeneration can be guaranteed.

In addition, in mammals, the RBC sanals are in two forms: one is the NLRBC sanals and the other is the NRBC sanals. These sanals have their own independent Bonghan Sanal—Cell Cycles. Interchanging these two processes does not occur once the animal is born. The Bonghan Sanal—Cell Cycle of NRBC sanals is the same as the typical cell Bonghan Sanal—Cell Cycle.

According to the cellation processes of the individual blood cell sanals, the differentiation/maturation processes

of various blood cells appear to have their own independent Bonghan Sanal—Cell Cycles.

9.2. Self-regeneration of blood cells follows the Bonghan Sanal—Cell Cycle in the meridian system

Cellation of blood sanals occurs in the meridian system. Blood cell sanals flow through mainly the internal Bonghan ducts, mature in internal Bonghan duct sinusoids inside the internal Bonghan corpuscles, and become blood cells. The process can be partly observed in the Bonghan corpuscles of other Bonghan subsystems. Inside the blood-producing organs, including the bone marrow, spleen, and lymph nodes, Bonghan duct sinusoids are particularly well developed and they have Bonghan corpuscle-like structure and functions. In the sinusoids, the cellation of blood cell sanals actively progresses.

Sanalization of blood cells also occurs in the meridian system. In other words, sanalization of blood cells occurs in the blood and lymphatic vessels inside respective Bonghan corpuscles.

October 8, 1965

Disclosure statement

The author declares that they have no conflicts of interest and no financial interests related to the material of this manuscript.

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